CLAIMS

1. A control apparatus for a single or multiple plug-dropping tool, comprising:

at least one signal transmitter for sending at least one signal over the air;

at least one signal receiver for receiving said signal from said transmitter and to provide an output;

at least one control system comprising a primary control element;

at least one signal processor to use said output from said receiver to selectively remotely operate said control element to allow release of a plug from the apparatus by said system.

2. The apparatus of claim 1, further comprising:

at least one final control element, said final control element selectively preventing and allowing a plug to drop from the apparatus, whereupon actuation of said primary control element selectively permits actuation of said final control element to drop a plug.

3. The apparatus of claim 2, wherein said control system further comprises:

a selectively releasable potential energy storage mechanism;

a force transfer mechanism connected to said potential energy mechanism and said final control element.

4. The apparatus of claim 3, wherein:

set and release of said potential energy storage mechanism is controlled by movement of said force transfer mechanism.

5. The apparatus of claim 4, wherein:

said force transfer mechanism further comprises a piston and cylinder combination;

said piston forming a first and second variable–volume cavity within said cylinder;

a fluid circuit connecting said first and second variable–volume cavities;

said primary control element further comprises a valve mounted in said fluid circuit.

6. The apparatus of claim 5, wherein:

said first and second cavities have volumes that vary inversely with movement of said piston;

said potential energy storage mechanism operably connected to said piston and cylinder combination;

said valve selectively fluid locking said piston with respect to said cylinder for securing said potential energy mechanism in a set position wherein a force is stored;

said valve, when selectively opened, fluid unlocking said piston for movement with respect to said cylinder;

whereupon said fluid unlocking of said piston allows said potential energy mechanism to apply said stored force to said piston cylinder combination, which in turn actuates said final control element to drop a plug.

7. The apparatus of claim 6, further comprising:

a rack operably connected to said piston and cylinder combination;

said final control element further comprises:

a pin;

a gear mounted to said pin, said gear selectively positionable in meshing contact with said rack;

an operator mounted to said pin;

said potential energy mechanism further comprises:

a spring fixedly mounted on one end and connected to said piston and cylinder combination;

said spring settable to store a force by virtue of operation of said operator which, through said gear, rotates said rack in a first direction when said fluid circuit permits flow in at least one direction;

said set being retained by selective operation of said valve to stop flow in said circuit;

whereupon selective opening of said valve allows said rack to drive said gear in a second direction opposite said first direction for release of the plug by rotation of said pin.

8. The apparatus of claim 7, further comprising:

a check valve in parallel with said valve in said circuit to permit one-way flow in said circuit to allow said rack to rotate in said first direction for setting a stored force in said spring;

said valve operable to facilitate flow in said circuit in a reverse direction for transmitting said stored force to said pin via said rack and gear.

9. The apparatus of claim 8, wherein:

said cylinder has one open end;

one of said variable-volume cavities disposed adjacent said open end;

a floating piston disposed between said piston and said cylinder adjacent said open end and movable relative to movements of said piston for dynamically sealing off said variable-volume cavity most adjacent to said open end.

10. The apparatus of claim 1, further comprising:

a plurality of signal receivers disposed around the periphery of the apparatus for allowing said signal transmitter to effect dropping the plug while the apparatus is rotating and/or reciprocating.

11. The apparatus of claim 9, further comprising:

a plurality of signal receivers disposed around the periphery of the apparatus for allowing said signal transmitter to effect dropping the plug while the apparatus is rotating and/or reciprocating.

12. The apparatus of claim 1, wherein:

at least one signal transmitter which sends a plurality of different signals;

a plurality of assemblies of said signal receivers, processors and primary control elements, each disposed on different parts of a multi-plug-dropping tool;

each of said receivers responsive to a discrete different signal from said transmitter for selective orderly dropping of a plurality of plugs into a well-bore.

13. The apparatus of claim 9, wherein:

at least one signal transmitter which sends a plurality of different signals;

a plurality of assemblies of said signal receivers, processors and primary control elements, each disposed on different parts of a multi-plug-dropping tool;

each of said receivers responsive to a discrete different signal from said transmitter for selective orderly dropping of a plurality of plugs into a well-bore.

14. The apparatus of claim 1, wherein:

said transmitter sends an infrared signal;

said transmitter, receiver and/or signal processor are built to be intrinsically safe.

15. The apparatus of claim 9, wherein:

said transmitter sends an infrared signal;

said transmitter, receiver and/or signal processor are built to be intrinsically safe.

16. A plug-dropping apparatus for downhole use, comprising:

at least one housing;

at least one plug selectively supportable within said housing;

at least one plug stop assembly selectively operable to hold and release said plug;

at least one signal transmitter;

at least one signal receiver on said housing for receiving over the air at least one signal from said transmitter;

at least one control system, said control system receiving an output from said signal receiver and in response thereto actuating said plug stop to release said plug.

17. The apparatus of claim 16, further comprising:

a plurality of said receivers distributed about said housing in a generally downward orientation;

whereupon said signal transmitter, operated from a safe location below said receivers, can direct said signal to at least one of said receivers as said housing rotates and/or reciprocates.

18. The apparatus of claim 17, further comprising:

a plurality of housings, each selectively retaining a plug and each equipped with at least one signal receiver and control system;

said receivers on each of said housings responsive to different signals from said transmitter to accomplish orderly release of said plugs from the lowermost housing to the uppermost.

19. The apparatus of claim 16, wherein said control system further comprises:

a biasing element;

at least one linkage operably connecting said biasing element to said plug stop assembly;

at least one lock mechanism mounted to said linkage for allowing selective movement thereof;

said lock mechanism operable to lock in a force into said biasing element and to selectively release said force so it can be transferred through said linkage to said plug stop assembly for release of said plug.

20. The apparatus of claim 19, wherein:

said lock mechanism comprises a variable length link in said linkage.

21. The apparatus of claim 20, wherein said variable length link comprises:

a piston and cylinder combination;

said piston selectively lockable by fluid force;

a fluid circuit in communication with said cylinder on opposed sides of said piston;

said control system further comprises:

a valve in said fluid circuit, said valve selectively operable to create a locking fluid force preventing piston movement and to release said locking force responsive to a signal from said transmitter.

22. The apparatus of claim 21, wherein:

said linkage comprises a rack;

said plug stop assembly comprises a pin;

said pin so disposed in said housing to selectively retain said plug and release it upon rotation;

a pinion gear operably connected to said pin and said rack;

said biasing means primed to store a force and said pin positioned to retain said plug by initial rotation of said pin in a first direction with said valve open, said stored force released by actuation of said transmitter to open said valve, which in turn transmits said stored force through said linkage to turn said pin in a second direction opposite said first direction for release of said plug.

23. The apparatus of claim 22, wherein:

said transmitter sends an infrared signal;

said transmitter, receiver, and/or control system comprise intrinsically safe electrical components;

said valve comprises a solenoid in said fluid circuit.

24. The apparatus of claim 23, further comprising:

a plurality of said receivers distributed about said housing in a generally downward orientation;

whereupon said signal transmitter, operated from a safe location below said receivers, can direct said signal to at least one of said receivers as said housing rotates or translates.

25. The apparatus of claim 24, further comprising:

a plurality of housings, each selectively retaining a plug and each equipped with at least one signal receiver and control system;

said receivers on each of said housings responsive to different signals from said transmitter to accomplish orderly release of said plugs from the lowermost housing to the uppermost.

26. A method of releasing balls or plugs for liner cementing, comprising the steps of:

erecting an apparatus to drop balls or plugs on a casing or liner string;

transmitting a signal over the air from a safe location to the remotely mounted apparatus;

receiving said over-the-air signal at the apparatus;

using the signal received to trigger release of at least one ball or plug.

27. The method of claim 26, further comprising the steps of:

providing a plurality of receivers on the apparatus;

rotating and/or reciprocating the apparatus as at least one of said receivers gets the signal to trigger said release.

28. The method of claim 27, further comprising the steps of:

stacking a plurality of said apparatuses ~~in series~~;

transmitting a plurality of said signals;

making a receiver in each apparatus responsive to a different signal for orderly release of the balls or plugs.

29. The method of claim 28, further comprising the steps of:

storing a force in a biasing device in said apparatus;

connecting the biasing device to a linkage;

connecting the linkage to a plug support assembly;

releasing said stored force;

using said released force to operate said plug support assembly through said linkage.

30. The method of claim 29, wherein:

priming said biasing device by moving said plug support assembly;

selectively fluid locking said linkage lock;

trapping a stored force in said biasing device with said locking;

using said transmitted signal to operate a valve for a subsequent unlocking;

releasing the ball or plug by said subsequent unlocking.

31. The apparatus of claim 12, wherein:

said transmitter sends a plurality of frequencies spaced in time;

at least one of said frequencies serving a dual purpose of being first a part of a received signal sent to said processor to allow said processor to issue

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an output signal to operate said primary control element, and second to act as a cue to said processor that an incoming multiple frequency signal has begun or has concluded.

32. The apparatus of claim 12, wherein:

said transmitter sends a plurality of frequencies;

said processor discriminates for said frequencies and generates an output signal to said primary control element based on the order of frequencies received.

33. The apparatus of claim 31, wherein:

at least a first and second frequency serve a dual purpose and are part of a sequence of signals that triggers an output from said processor;

said first frequency is first in time and cues said processor that a multifrequency signal is arriving, said second frequency is last in time and cues said processor that a multifrequency signal is fully transmitted, thus triggering said processor to issue an output signal for actuation of said primary control element.

34. The apparatus of claim 33, wherein:

said receiver further comprises a self-contained power supply;

interlock means on said power supply to prevent actuation of said primary control element unless a preset value of power exists for a preset time.

35. A control system useful in outdoor environments for operating a controlled element, comprising:

at least one transmitter for sending at least one signal over the air;

at least one signal receiver for receiving a signal from said transmitter to provide an output;

at least one signal processor to receive the output of said receiver and to generate a command signal to the controlled element;

said transmitter sends a plurality of frequencies;

said processor discriminates for said frequencies and generates an output signal to said primary control element based on the order of frequencies received.

36. The apparatus of claim 35, wherein:

said transmitter sends a plurality of frequencies spaced in time;

at least one of said frequencies serving a dual purpose of being first part of a received signal sent to said processor to allow said processor to issue an output signal to operate a primary controlled element, and second to act as a cue to said processor that an incoming multiple frequency signal is about to come or has concluded.

37. The apparatus of claim 36, wherein:

at least a first and second frequency serve a dual purpose and are part of a sequence of signals that triggers an output from said processor;

said first frequency is first in time and cues said processor that a multifrequency signal is arriving, said second frequency is last in time and cues said processor that a multifrequency signal is fully transmitted, thus triggering said processor to issue an output signal for actuation of the primary controlled element.

38. The apparatus of claim 37 wherein:

said receiver further comprises a self-contained power supply;

interlock means on said power supply to prevent actuation of the primary controlled element unless a preset value of power exists for a preset time.